CLINICAL GUIDELINE | PNEUMONIA COMPLICATED BY EMPYEMA: INITIAL DIAGNOSIS/MANAGEMENT

(Age 3 months–24 years)

Children's MINNESOTA

Aim: To standardize management of patients with empyema.

Patient with signs/symptoms of empyema:
Fever, cough, increased WOB (See Note 1)
PLUS
Effusion seen on CXR
OR
Diagnosed with Pneumonia and clinical worsening on appropriate therapy (see Pneumonia Guideline)

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Initial Assessment
- Assess for sepsis (See Note 2)
- Pulse-oximeter, start supplemental oxygen if O2 sats < 90%
- Consider high flow nasal cannula if increased WOB.
- Place PIV, provide IVF, analgesia/anti-pyretics
- Obtain initial labs (**BEFORE** antibiotics): CBC w/differential, CMP, CRP, blood culture, nasal MRSA PCR
- COVID/influenza testing if indicated.

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Obtain Imaging
- AP/Lateral decubitus CXR
- Ultrasound chest if suspecting moderate-large effusion (see Note 3)
- CT scans **not** routinely indicated

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Effusion > 1 cm and occupies > ¼ of hemithorax or compromises breathing?

← No

Significant empyema unlikely
- Return to Community Acquired Pneumonia Guideline
- Consider ID/Pulmonary consult
- Consider re-imaging if no improvement in 24–48 hours

↓ Yes

Significant effusion, empyema is possible.
- NPO with IVF
- Provide analgesia
- Educate caregivers about empyema (see Note 4)
- Order appropriate antibiotics (see Page 3)

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Admit to PICU/IMC for chest tube placement and management.
- Obtain consent for chest tube
- Plan deep sedation
- Place chest tube: size 8–12 Fr
- Consider PICC or central line placement
- Consider NG placement for nutrition support
- Send pleural fluid in capped syringe for cell count, gram stain, culture (aerobic and anaerobic) and save sample (≥ 1 mL frozen) for further testing (including 16s [bacteria] and 18s [fungi] rRNA PCR). Order the aerobic culture as "body fluid."
- Consult Pulmonary
- Consult **Infectious Disease** if concern about staphylococcal infection, infection due to unknown or unusual organism (e.g. anaerobes, gram-negative, Mycobacteria, necrotizing pneumonia or lung abscess), or failure to improve

EXCLUSION GUIDELINES

Patients **excluded** from this guideline:
- Immunodeficiency, sickle cell disease, CF, tracheostomy, or neurological impairment
- NICU patient
- Hospital-acquired or postprocedural empyema

INPATIENT OR PICU GUIDELINE

PNEUMONIA COMPLICATED BY EMPYEMA: ONGOING MANAGEMENT

(Age 3 months–24 years)

Children's MINNESOTA

Aim: To standardize management of patients with empyema.

Patient with Empyema, s/p Chest Tube placement
- Obtain CXR to confirm tube position
- IV/PO acetaminophen
- IV ketorolac/PO ibuprofen if renal function adequate
- Consider hydromorphone PCA
- Continue empiric antibiotics (see Page 3)
- Consider NG feedings (see Note 5)
- Bowel regimen
- Pulmonary and child life consult

Begin intrapleural tPA
- Pt < 10 kg: Give 4 mg tPA dissolved in 10 ml NS then a 5 ml NS flush
- Pt ≥ 10 kg: Give 4 mg tPA dissolved in 20 ml NS then a 5 ml NS flush
- Continue tPA once daily x 3 days
- Consider intrapleural DNase (in addition to tPA) if pleural WBC > 10,000 (see Note 6)

Repeating labs/imaging
- Repeat Hgb and CRP every other day. BMP and albumin daily if primarily on IVF, otherwise every other day. (See Note 7)
- Repeat CXR daily while chest tube is present

Assess need for vancomycin daily

All of the following present?
- < 10–15 ml of chest tube output per 24 hours
- Improved effusion on CXR
- Improved fever curve, CRP, oxygen needs, and PO intake

No
- Consider repeat US to evaluate for loculations
- Consult gen. surgery for possible VATS if not improving after several days of chest tube drainage

Yes

Remove chest tube
- Tube to be removed by PICU team
- Repeat CXR after removal to assess for pneumothorax

Start oral antibiotics (see Note 8) **when:**
- Tolerating PO, chest tube removed, and culture results and sensitivities are known

Discharge Criteria
- Tolerating consistent PO
- On room air
- Improving fever curve
- Improving CRP
- Caregivers comfortable with follow-up
- PCP f/u in 2–4 days
- Pulmonary f/u 1 week via telehealth and 3 months in person w/ CXR
- Antibiotic course: 14–21 days after pleural fluid drainage (21–28 days if staphylococcal)

EXCLUSION GUIDELINES

Patients **excluded** from this guideline:
- Immunodeficiency, sickle cell disease, CF, tracheostomy, or neurological impairment
- NICU patient
- Hospital-acquired or postprocedural empyema

PNEUMONIA COMPLICATED BY EMPYEMA: ANTIBIOTICS

(Age 3 months–24 years)

Children's MINNESOTA

Aim: To standardize management of patients with empyema.

Initial IV antibiotics:
Ceftriaxone 50 mg/kg q12h (max: 2,000 mg/dose)*

If severe cephalosporin allergy:
Levofloxacin
- 6 mo to < 5 years: 10 mg/kg/dose IV q12h (max 375 mg/dose)
- ≥ 5 years: 10 mg/kg/dose IV q24h (max 750 mg/dose)

Hypotension or requiring vasopressors
OR
Prior respiratory isolation of MRSA
OR
Hospitalization & IV antibiotics within 90 days
OR
Influenza positive

Yes → **Add Vancomycin** 15 mg/kg q6h if < 18 years old or 15–20 mg/kg IV q12h if 18–24 years old (trough goal 15–20 mg/L)

Positive Nasal MRSA PCR

Yes → Consider discontinuing vancomycin if cultures negative for MRSA

No → Consider discontinuing vancomycin if patient improving within 24–48 hours

No → **Do not add vancomycin**

Positive Nasal MRSA PCR

Yes → Assess need for MRSA coverage based on cultures and clinical response to current regimen

No → Continue current regimen

Nasal MRSA PRC
- Negative predictive value (NPV) is high (~98% based on adult data in uncomplicated CAP), so **negative** result is **good** predictor of **no** MRSA pneumonia
- Positive predictive value (PPV) is low (~50% based on adult data in uncomplicated CAP), so **positive** result is **poor** predictor of MRSA pneumonia

* **Ceftriaxone** q12h dosing is intended for better empiric coverage of MSSA compared to q24h dosing. If MSSA is isolated consult Infectious Disease.

Transition to oral antibiotics (see Note 8) **when:**
Tolerating PO, chest tube removed, and cultures and sensitivities known
Options based on tolerance, cultures, and allergies:
- **Amoxicillin** 30 mg/kg/dose PO TID (max 1250 mg/dose)
- **Cephalexin** 25 mg/kg/dose PO TID (max 1250 mg/dose)
- **Amoxicillin/clavulanate** 45 mg amoxicillin/kg/dose PO BID (max 2000 mg amoxicillin/dose) (use 14:1 formulation)
- **Cefdinir** 7 mg/kg/dose PO BID (max 300 mg/dose)
- **Clindamycin** 10 mg/kg PO TID (max 600 mg/dose)
- **Cephalosporin allergy: Levofloxacin** 10 mg/kg/dose PO BID if 6 months to < 5 years (max 375 mg/dose); 10 mg/kg/dose PO daily if ≥5 years (max 750 mg/dose)

Aim: To standardize management of patients with empyema.

NOTE 1. **Signs/symptoms** of complicated pneumonia include: Cough, fever, increased work of breathing, crackles on lung exam. Differential diagnosis includes: CHF, foreign body, pertussis, measles, TB, aspiration, empyema/abscess, fungal/viral infection, atypical pneumonia, bronchiolitis/viral pneumonia, inhalation injury, asthma, lung malformation. Organisms commonly involved in empyema include: *Streptococcus pneumoniae, Streptococcus pyogenes* (GABHS), *Streptococcus viridans* and *Staphylococcus aureus* (MRSA and MSSA).

NOTE 2. **Sepsis.** Patients with bacterial infections such as pneumonia/empyema are at increased risk for SIRS (systemic inflammatory response syndrome) or sepsis, as well as respiratory failure (e.g. high work of breathing, retractions, nasal flaring, head bobbing, tachypnea).

SIRS: > 1 of (must include either temp/WBC):
- Temp > 38.5 (> 38 if < 2 mo age) or < 36
- Tachycardia (or bradycardia if < 1 yr age)
- Tachypnea
- WBC < 5,000 or > 15,000 or > 10% bands

Sepsis: SIRS + suspected infection

Severe Sepsis: Sepsis + CV dysfunction or ARDS or 2+ organ dysfunctions

Septic Shock: Sepsis + CV dysfunction that persists after ≥ 40 mL/kg NS in one hour

NOTE 3. **Effusion sizing.** Effusions < 10 mm, or < ¼ hemithorax are considered mild. Moderate or large effusions are > 10 mm and occupies ½ of the hemithorax or if they compromise breathing.

NOTE 4. **Caregiver education.** Empyema is defined as pneumonia that has extended beyond the surface of the lung to infect the space and lining of the inside of the chest wall. Patient with empyema have a 10–20% chance of failing medical therapy (antibiotics + chest tube + intrapleural medications) and may require a VATS (video-assisted thorascopic surgery) procedure to remove infectious debris from inside the chest. Average hospital length of stay for patients with empyema is 9 days. Children who experience an empyema are not typically prone to future lung infections and are expected to have normal lung function after appropriate recovery.

NOTE 5. **Nutrition.** Patients with empyema are at risk for malnutrition due to poor oral intake during illness and ongoing protein losses. Consider NG placement for early enteral nutrition support. Provide bowel regimen (e.g. polyethylene glycol and senna) to prevent constipation in setting of inactivity and opioid medications.

NOTE 6. **Intrapleural DNase** is generally not recommended. An RCT found no differences in outcomes in patients treated with both tPA plus DNase compared with tPA plus placebo (Livingston et. al. JAMA Pediatrics 2020). Consider in patients with a pleural WBC of > 10,000. DNase 5 mg is dissolved in 10 ml NS for patients < 10 kg and 20 ml NS for patients ≥ 10 kg and followed by 5 ml NS. DNase is administered at least 2 hrs after tPA. DNase is never used as the sole intrapleural agent.

NOTE 7. **Lab notes.** Close attention must be paid to fluid balance and sodium as patient with empyema are at risk for SIADH (syndrome of inappropriate antidiuretic hormone secretion). Albumin may become very low in patients with empyema (< 2.0) due to leakage of proteins into the pleural space and has been identified as a predictive risk factor for empyema in patients suspected of having pneumonia (Chalmers et. al. 2009).

NOTE 8. **Antibiotic notes.** A comparative effectiveness study, using propensity score-weighted logistic regression, found no difference in outcomes between patients discharged on oral antibiotics compared with those discharged with IV (e.g. PICC) antibiotics (Stockmann et.al. 2015). A multicenter cohort study of 2123 children with parapneumonic effusion and empyema had similar findings (Shah et.al. 2016). **Duration** of antibiotic therapy is influenced by the organism, adequacy of source control, and clinical response. For non-staphylococcal disease, typical antibiotic course is 14–21 days after pleural fluid drainage. Staphylococcal disease may require therapy for 3–4 weeks. Choose the **narrowest** appropriate oral antibiotic based on susceptibility results (e.g. amoxicillin for *Streptococcus pneumoniae or Streptococcus pyogenes).*

Aim: To standardize management of patients with empyema.

Key Outcome Measures

- Proportion of patients evaluated for empyema with chest ultrasound vs. chest CT
- Proportion of patients with negative nasal MRSA PCR and vancomycin discontinued

Key Balancing Measures

- Length of stay
- Unplanned outpatient visits/readmissions in first 14 days

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Aim: To standardize management of patients with empyema.

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